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Wiedemann, Daniel P. O. ORCID logoORCID: <https://orcid.org/0000-0001-9053-6471>,
Passmore, Peter J. ORCID logoORCID: <https://orcid.org/0000-0002-5738-6800> and Moar,
Magnus ORCID logoORCID: <https://orcid.org/0000-0002-9489-9795> (2017) Local multiplayer
immersion affected by 3D stereoscopy. CHI PLAY '17 Extended Abstracts Publication of the
Annual Symposium on Computer-Human Interaction in Play. In: CHI PLAY 2017, 15-18 Oct
2017, Amsterdam. ISBN 9781450351119. [Conference or Workshop Item]
(doi:10.1145/3130859.3131429)

Final accepted version (with author's formatting)

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Local Multiplayer Immersion Affected by 3D Stereoscopy

Daniel P. O. Wiedemann

Department of Media
Middlesex University
London, NW4 4BT, UK
d.wiedemann@mdx.ac.uk

Peter Passmore

Department of Computer Science
Middlesex University
London, NW4 4BT, UK
p.passmore@mdx.ac.uk

Magnus Moar

Department of Media
Middlesex University
London, NW4 4BT, UK
m.moar@mdx.ac.uk

Author Keywords

3D Stereoscopy;
Local Multiplayer;
Immersion; Experiment;
Nicely Dicely.

**ACM Classification
Keywords**

K.8.0. General: Games;
H.5.2 Information Inter-
faces and Presentation
(e.g., HCI): User Inter-
faces--- Evalua-
tion/methodology,
Graphical user interfaces
(GUI); H.5.m Infor-
mation Interfaces and
Presentation (e.g., HCI):
Miscellaneous.

Abstract

In this paper, we describe an experimental study, which evaluates how 3D stereoscopy affects player immersion in a possibly very distracting local multiplayer game. The game “Nicely Dically” was specifically developed for this purpose, with 3D stereoscopy in mind, right from the beginning. Groups of participants were competitively playing the game in non-3D monoscopic and 3D stereoscopic presentations via a 3D compatible projector and corresponding active shutter glasses. In the following, we elaborate on the game and our quantitative and qualitative hybrid experiment design and methodology. An analysis of the resulting data will show that, indeed 3D stereoscopy significantly increases spatial presence, involvement and player immersion, even in a local multiplayer situation. Furthermore, some guiding insights relating the game’s design will be illustrated.

Introduction

This paper is going to investigate if and how stereoscopic 3D vision can affect immersion, a crucial aspect of gaming experiences. Furthermore, it is going to do that in the context of a local multiplayer game. By concept, this leads to several players being present in the same room and thus a possibly very distracting gaming experience, due to chatting and banter, which happened in varying degrees during our experiment sessions. Local multiplayer and the game being specifically developed for 3D, differentiates this study from others.

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CHI PLAY’17 Extended Abstracts, October 15–18, 2017, Amsterdam, Netherlands.

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ACM ISBN 978-1-4503-5111-9/17/10...\$15.00

<https://doi.org/10.1145/3130859.3131429>

Thus, our main hypothesis is: “3D stereoscopic vision increases player immersion, even in a possibly distracting local multiplayer game.”.

To evaluate this relation, we developed the game Nicely Dicer from scratch, while being compatible to stereoscopic 3D, right from the start. Optimized for 3D, the game takes place on one screen, omitting any drastic depth animations, and is visually positioned slightly “behind the screen”, to reduce any eye strain. Internal testing showed, that the game’s fundamental gameplay principle seemed to provide great fun among players, especially due to its local multiplayer concept.

Related Work

The following will give a broad overview of research relating to measuring and evaluating player immersion in digital games, stereoscopic 3D related design practices and challenges and analyzing the effect of 3D stereoscopy on player immersion.

Defining Immersion

The term immersion is still an area for great discussion on properly defining and measuring this experiential aspect. Summarizing the work of Slater et al. on a “Framework for immersive virtual environments (FIVE)” [17], Jerald states that “Immersion is the objective degree to which a VR [virtual reality] system and application projects stimuli onto the sensory receptors of users in a way that is extensive, matching, surrounding, vivid, interactive and plot informing.” [6]. Jerald further elaborates on these six aspects of immersion: Extensiveness correlates to the amount of different sensory inputs for the user (e.g. visual, auditory and haptic), matching means the congruence of these inputs to the user’s interactions (e.g. visual representa-

tion reflects head movement appropriately), surrounding addresses the degree of panoramanness (e.g. spatialized 3D audio, FOV and 360 degree tracking), vividness correlates to the output quality and resolution (e.g. screen refresh rate, resolution and audio quality), interactibility concerns the degree in which a user can influence the virtual environment (VE) including its characters and objects and finally informing on the plot, addresses the consistency of how the story of the experience is presented [6]. In combination and possibly varying configurations, these aspects are supposed to make up the sense of immersion in VR [17].

Concerning “presence” [5], Slater and Wilbur express that it “may be concomitant with immersion” [17] but does not have to be and Jerald supports this notion by explaining “immersion does not always induce presence” [6]. So, contrary to the feeling of presence, which seems to be intrinsic to VR only [6], we argue that the FIVE concept is also true for non-VR applications (e.g. monoscopic digital games). Only the degree of immersion is decreased by the used technology. Furthermore, this study will look more closely into the aspect of extensiveness. Specifically, it will show that 3D stereoscopy, compared to a non-3D monoscopic presentation, can increase player immersion, even in a highly distracting local multiplayer situation.

Analyzing Immersion and Presence

Trying to develop “more quantifiable and therefore objective measures of immersion” [1], Cairns et al. conducted an experiment, in which subjects were switched from playing an immersive game to performing a different task. They argue, that the degree of immersion could be measured, by observing the differences in the subject’s performance in real-world tasks,

after he or she transferred from performing immersive game tasks [1]. The study seemed to infer this relation, though Cairns et al. could not clearly distinguish, if just certain aspects of immersion were causing this effect [1]. Additionally, the experiment design was highlighted as complex and interruptive. Thus, it was suggested to test a combination of eye tracking and body motion analysis instead [1]. These measurement strategies seemed rather complex in a within-subjects experiment design with multiple parallel participants, which is why it was discarded for our experiment.

In terms of self-evaluating overall presence in a VE, the Igroup presence questionnaire (IPQ) seems rather promising, on the other hand [15] and [4]. Originally based on a combination of works of Slater and Usoh [16], Witmer and Singer [18], Hendrix [3], Carlin et al. [2] and Schubert et al. [14], the questionnaire was condensed to 14 questionnaire items. These items lead to the four sub scales "general presence", "spatial presence", "involvement" and "experienced realism" [4], which in turn lead to an overall presence scale. Due to its critically discussed empirical foundation, its evaluation and adjustment through several iterations with over 500 participants, corresponding factor analyses and finally its practicality by consisting of only 14 questions, the IPQ seems both settled and fit enough for assessing presence (and its subpart immersion) in a practical but thorough manner. This led to the decision of using a subset of the questionnaire for evaluating player immersion in this study.

3D Stereoscopy

By investigating Nintendo's Virtual Boy (VB), Zachara et al. uncovered various pitfalls with certain stereoscopic 3D

gaming concepts [19]. They extrapolated six different reasons, which led to the VB's failure: "Undefined product identity", "Weak display", "Challenges in explaining and demonstrating", "Negative effects", "Lack of killer app" and "Isolating game experience" [19]. The first four aspects tend to be more specific to the VB device. With better 3D stereoscopic technologies, with higher display refresh rates, negative effects generally decreased drastically. The lack of a "killer app" currently persists though, as only few games make use of 3D stereoscopy. In terms of isolating users: Our local multiplayer experiment, clearly shows that the opposite is possible nowadays.

In their more current study on design practices and challenges in stereoscopic 3D video games, Mahoney et al. stated that "Stereoscopic 3D in games can enhance immersion under certain conditions." [12]. They further stated how crucial it is, to design the game for stereoscopic 3D from the ground up [12]. Overlaying head-up-displays (HUDs) need to properly work in 3D, or different design paradigms should be used instead [12]. Furthermore, "Stereoscopic 3D can offer new possibilities for new games types." [12]. Our study will further elaborate on the issue of properly implementing HUDs and possible gameplay improvements through stereoscopic 3D.

Litwiller et al. investigated quantitative and qualitative measures of players' in-game performance and learning rates in stereoscopic 3D, throughout five different digital games [10]. Though subjects preferred the 3D stereoscopic over the non-3D monoscopic presentations, the study could "not provide any significant advantage in overall user performance." [10]. Our study will show a similar outcome, in terms of in-game performance.

Using an immersive 3D stereoscopic CAVE-like installation, Lugin et al. investigated user experience and player performance of a first person shooter (FPS), in comparison to its non-3D monoscopic desktop equivalent [11]. Their study showed “an overwhelming subjective preference for the immersive [3D stereoscopic] version” [11]. Player performance decreased in this setup though, because of the “more realistic aiming mechanism [with a wand-like controller]”, compared to the keyboard and mouse desktop setup [11]. As expected, experiment results confirmed significantly higher scores on spatial presence and engagement scales for the CAVE-like setup compared to the desktop one. Concerning 3D stereoscopy, the results of our experiment will show a similar tendency in increasing player immersion, but will not be biased by varying screen sizes, controllers, field of views or body engagement.

With 60 participants, Schild et al. investigated the specific effects of 3D stereoscopy on user experience in three digital games [13], presented in 3D stereoscopic and non-3D monoscopic vision, of which none were primarily developed for 3D, though [13]. To evaluate user experience, self-reporting via questionnaires and a headset measuring electroencephalogram (EEG) data were used [13]. Their results showed, that stereoscopic 3D is preferred over monoscopic non-3D, as it “increases experiences of presence and immersion” and EEG data indicate that 3D stereoscopy provides “a more natural player experience” via “a more direct and unconscious interaction” with the games [13]. Despite using slightly different user experience evaluation tools, our experiment’s results will also confirm an increase in immersion through 3D stereoscopy.

Lack of Stereoscopic 3D Local Multiplayer Literature

Reviewing related work has shown a lack of literature in the specific field of exploring the effects of stereoscopic

3D on immersion in a possibly distracting local multi-player environment. Verifying some outcomes of the previously mentioned more general studies, our experiment will step in this gap, by evaluating play sessions with the specifically developed game Nicely Dicely.

The Game: Nicely Dicely

Nicely Dicely (see Figure 1) is a 3D local multiplayer physics-based game, for up to four simultaneous players. The whole game takes place on one screen. Each player controls one special player cube (see numbered cubes in Figure 1) on a floating and dynamically changing playing board. Additionally, there are also passive score cubes (golden at the start), explosive mines and occasionally a “mystery crystal” (see Figure 1).

The goal is to score as many points as possible during a match and the player with the highest score at the end wins. There are several ways of affecting one’s score count. By touching a score cube, it gets tinted with the color of the player touching it (see unnumbered blue

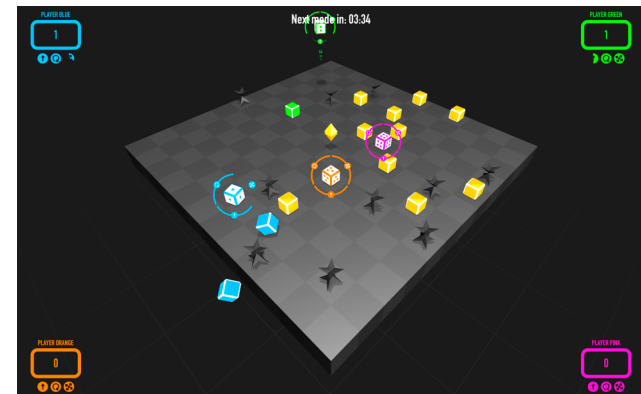


Figure 1: Nicely Dicely experiment version



Figure 2: Nicely Dically Mystery: Board Deletion



Figure 3: Nicely Dically Mystery: Board Displacement

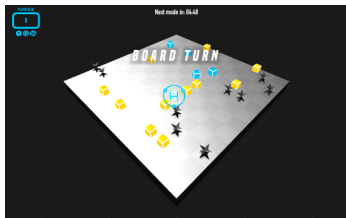


Figure 4: Nicely Dically Mystery: Board Turn

cubes in Figure 1). If this score cube gets pushed off or otherwise falls off the board, the player with that color scores a point. If a player cube for some reason falls off the board itself, one score point gets subtracted.

The game's board, consists of 12 x 12 separately addressable level cubes. Three special scenarios, the "mysteries", were implemented additionally to the game board's neutral condition. In "Board Deletion" (see Figure 2), a random selection of level cubes would be temporarily scaled down, so the board would be filled with holes. In "Board Displacement" (see Figure 3), a random selection of level cubes would be temporarily moved upwards, thus creating a sort of maze. In "Board Turn" (see Figure 4), the board would be turned by 180 degrees and thus players had to use inverted controls, as suddenly up was down and left was right. Chosen randomly, one of the mysteries would be triggered, once a player cube activated the central mystery crystal, which spawns after a certain amount of time.

Besides steering movement of the player cubes, players could perform three actions: jump, bounce and spin. Bounce would perform a physics explosion, giving surrounding cubes a push. Spin would quickly roll the player cube in the current direction. Each player action would be limited in use by an individual cooldown time. The corresponding cooldown times were visualized by watch face icons in the corresponding corner HUDs (see Figure 1), as well as three expanding arches forming a ring HUD around each player cube (see Figure 1).

A number of score cubes and mines were randomly placed on the board with each start of a match. When a

mine (see spikey objects in Figure 1) was touched by a score or a player cube, a light explosion would spread the surrounding cubes, also possibly over the board.

Technically, Nicely Dically can be played on macOS and is optimized for up to four Xbox controllers, including their rumble functionality. The game can either be played in monoscopic or stereoscopic 3D mode (side-by-side 3D), if a compatible 3D TV or 3D projector is used (see overlapped 3D simulation in Figure 7).

Experiment Methodology

The hardware setup for the experiment included an Apple MacBook Pro (Mid 2012), four Xbox controllers, a Panasonic PT-AT6000E 3D projector and four pairs of Panasonic TY-EW3D3ME 3D IR active shutter glasses. All user test sessions were video recorded (see Figure 6), to capture verbal remarks and gaming behavior.

By filling out the consent form, the participants agreed to the experiment terms and provided basic information about themselves and their experience with digital games and 3D stereoscopy. The main goal for the subjects was communicated as achieving the highest score possible, by pushing the golden score cubes off the game board, while themselves not falling off the board and thus losing score points. Each mode and thus each match would end after five minutes.

The procedure of the user test is explained to participants as followed: The experiment will go through three different phases. Each will last for 5 minutes and reset the game automatically afterwards, resulting in a total play session duration of ~15 minutes (see Figure 5).



Figure 6: Experiment setup



Figure 7: Nicely Dicerly overlapped stereoscopic 3D simulation



Figure 5: Experiment phases

The first phase will be monoscopic like in any other regular flat game, so subjects can generally make themselves familiar with the game first. In the subsequent phases, two modes will be tested, one again monoscopic and the other in 3D stereoscopic. The order of these two modes will be pseudo random, to counter balance any order effects. While playing, a countdown is visible, showing the remaining time of the current mode (see Figure 1). An edited video of the procedure, the monoscopic and stereoscopic modes, as well as excerpts of the user sessions can be watched at: <https://vimeo.com/wiedemannnd/immersionaffectedby3dstereoscropyexperimentoverview>

Based on the two immersion concerning sub scales "spatial presence" and "involvement" of the IPQ [15] and [4], a questionnaire specific to the experiment was developed, which would be filled out after the play testing phases. Separated into three sections, the participants were asked to evaluate their gaming experience in the "Non-3D Monoscopy Mode", "3D Stereoscopy Mode" and in "General". Based on the IPQ [15] and [4], to assess mode related player immersion, the first two sections each provide the following statements, to be rated by subjects on a 7-point Likert scale from "Strongly disagree" to "Strongly agree": "Somehow I felt that the virtual world surrounded me.", "I felt like I was just perceiving pictures.", "I did not feel present in the virtual space.", "I had a sense of acting in the vir-

tual space, rather than operating something from outside.", "I felt present in the virtual space.", "I was completely aware of the real world surrounding while navigating in the virtual world (i.e. sounds, room temperature, other people, etc.).", "I was not aware of my real environment.", "I still paid attention to the real environment." and "I was completely captivated by the virtual world.". Relating to the earlier discussed connection between presence and immersion [17] and [6], and as the experiment is assessing a change caused by 3D stereoscopy, which drastically affects the perception of virtual space, we chose to additionally combine the two IPQ sub scales spatial presence and involvement to an overall "immersion" scale for this investigation. This arguably enhances capturing the effect of 3D stereoscopy on immersion, instead of only relying on the involvement sub scale.

In the third section, participants are asked for their personal mode preference and their reasoning for their decision. Two further free text questions gave subjects space for concrete and individual feedback.

Besides, the experiment application tracked the following in-game parameters for each player per mode: player score, player deaths and player performance for analysis. Player performance is the calculated ratio between player score and player deaths.

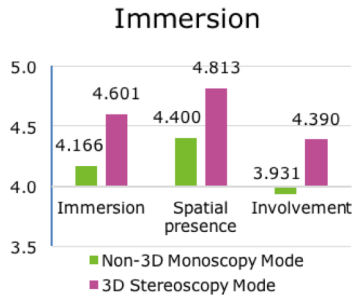


Figure 8: Diagram for Immersion

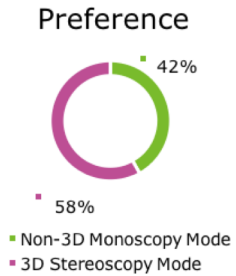


Figure 9: Diagram for Preference

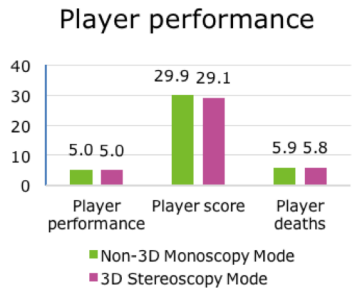


Figure 10: Diagram for Player performance

Experiment Results

The experiment was conducted with 31 participants (total $n = 31$), partly knowing each other, of which 24 were male and 7 were female. Ages ranged from 18 to 57 years and averaged at 22 years. According to the statement "I am an experienced digital game player", 4 were rather inexperienced (< 4 on 7-point Likert scale) and 27 rather experienced (≥ 4) subjects, with a total mean of 5.68. Rather little experience with 3D stereoscopy noted 8 (< 4 on 7-point Likert scale) and rather more experience was noted by 23 (≥ 4) of the participants, with a total mean of 4.71. 4 subjects noted, they were playing digital games between "less than once a year" and "once every some months", one single participant noted she was playing "once a month" and 26 marked they would play digital games between "once or twice a week" and "every day".

Immersion, Spatial Presence and Involvement

Three separate paired-samples t-tests [7] and [9] were used to determine whether there were statistically significant mean differences on the immersion, spatial presence and involvement 7-point Likert scales between presenting the game in 3D stereoscopic mode compared to non-3D monoscopic mode. To preserve easy comparability with the original 7-point Likert scale

format, the means (not sums) of item scores were used to calculate the resulting scales, before performing the t-tests.

There were no outliers in the overall immersion data, as assessed by inspection of a boxplot. Scores were normally distributed with a skewness of -0.305 ($SE = 0.401$) and kurtosis of 0.052 ($SE = 0.821$). Data are mean \pm standard deviation, unless otherwise stated. Participants experienced stronger immersion when the game was presented in 3D stereoscopy (4.601 ± 0.887) as opposed to non-3D monoscopy (4.166 ± 0.923). The 3D stereoscopic mode compared to the non-3D monoscopic mode elicited a statistically significant mean increase on the immersion scale of 0.435 (95% CI, 0.089 to 0.781), $t(30) = 2.565$, $p = 0.016$ and $d = 0.461$ (small to medium effect size).

Two outliers were detected in the spatial presence data, that were more than 1.5 times the inter-quartile range (IQR) from the edge of the box in a boxplot (see Figure 11). Inspection of their values did not reveal them to be extreme (< 3 IQR) and they were kept in the analysis. Scores were normally distributed with a skewness of -0.350 ($SE = 0.421$) and kurtosis of -0.222 ($SE = 0.821$). Data are mean \pm standard deviation, unless

	a) Immersion		b) Preference	c) Player performance	
	Spatial presence	Involvement		Player score	Player deaths
Non-3D Monoscopy Mode	4.166 ± 0.923		42% (13)	5.040	
	4.400 ± 0.788	3.931 ± 1.498		29.94 ± 14.938	5.94 ± 5.285
3D Stereoscopy Mode	4.601 ± 0.887		58% (18)	5.001	
	4.813 ± 0.879	4.390 ± 1.237		29.10 ± 13.524	5.81 ± 4.370

Table 1: a) Immersion: means \pm standard deviation of immersion, spatial presence and involvement on a 7-point Likert scale. b) Preference: Percentages (subject count) of directly chosen presentation mode preference. c) Player performance: means \pm standard deviation of player score, player deaths and the subsequently calculated player performance.

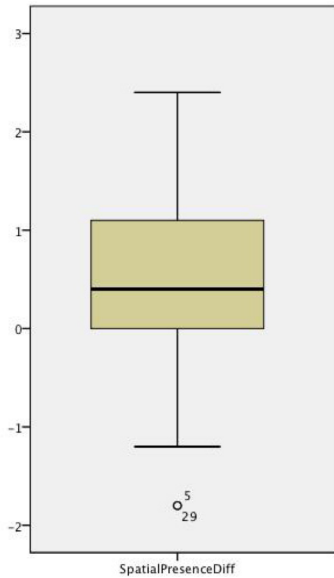


Figure 11: Spatial presence data
Tukey boxplot (whiskers showing
1.5 IQR)

otherwise stated. Participants experienced stronger spatial presence when the game was presented in 3D stereoscopy (4.813 ± 0.879) as opposed to non-3D monoscopy (4.400 ± 0.788). The 3D stereoscopic mode compared to the non-3D monoscopic mode elicited a statistically significant mean increase on the spatial presence scale of 0.413 (95% CI, 0.021 to 0.805), $t(30) = 2.150$, $p = 0.040$ and $d = 0.386$ (small to medium effect size).

There were no outliers in the involvement data, as assessed by inspection of a boxplot. Scores were normally distributed with a skewness of -0.029 ($SE = 0.421$) and kurtosis of -0.862 ($SE = 0.821$). Data are mean \pm standard deviation, unless otherwise stated. Participants experienced stronger involvement when the game was presented in 3D stereoscopy (4.390 ± 1.237) as opposed to non-3D monoscopy (3.931 ± 1.498). The 3D stereoscopic mode compared to the non-3D monoscopic mode elicited a statistically significant mean increase on the involvement scale of 0.457 (95% CI, 0.016 to 0.898), $t(30) = 2.118$, $p = 0.043$ and $d = 0.380$ (small to medium effect size).

The statistically significant increases in the quantitative data on spatial presence, involvement and immersion (see Table 1a and Figure 8), relating to the 3D stereoscopic presentation of the game, contribute to qualitative feedback and the following further comments: "3D felt like I was in the actual game (inside)", "It felt more interactive [in 3D mode]" and "I preferred the 3D mode because it was more engaging and also captured my attention more".

Mode Preference

The answers to the direct question "Which mode did you prefer?" ranked the 3D stereoscopic mode on the

first place with 58% and the non-3D monoscopic mode on the second place with 42% (see Table 1b and Figure 9). A chi-square goodness-of-fit test [7] and [8], with a minimum expected frequency of 15.5, indicated that the distribution of mode preference by participants in this study was not statistically significantly different ($\chi^2(1) = 0.806$, $p = 0.369$).

Nevertheless, by investigating the free text answers of participants, the following insights were extrapolated, in relation to the subjects' chosen preferences.

Five subjects, which preferred non-3D, commented that this presentation was not straining their eye sight as much as it did in 3D. Also, an additional effort in concentration was noted, when playing in 3D. Others who preferred non-3D additionally mentioned not perceiving a great difference at all between the two modes. These attitudes could be noticed as well in corresponding subjects commenting on how gameplay was affected: "3D was more obstructive. I found it more difficult to navigate the map.", "It made me think what I had to do to overcome the problem" and "I did not notice much difference".

On the other hand, participants who preferred the 3D stereoscopic presentation of the game highlighted the following positive aspects. Relating to the previous results on increased immersion in stereoscopic 3D, corresponding subjects clearly emphasized this mode's positive effect: "I found it more captivating", "[I preferred 3D because of the] immersion into the world" and "with the glasses you make your brain just focus on the screen and everything else loses importance". This aspect was amplified by the perceived "realness" of the game through 3D stereoscopy: "Putting on 3D glasses felt more real!" and "everything felt like it had a real impact, both my

actions and the cubes". Contributing to an increased graphical attractiveness participants furthermore highlighted: "The 3D mode was more visually appealing" and "In the 3D mode, the effects were a lot more enhanced.". Furthermore, 3D stereoscopic presentation of the game also seemed to enforce more fun: "Fun, interactive" and "It was more fun in the 3D Stereoscopic". Finally, the stereoscopic vision seemed to improve controls: "You have more attachment with the movement of the dice as perspective works well." and "The objects featured in the game seemed to 'pop out' more, and perceiving the 3D world was easier in 3D.". Adding to this aspect of affecting gameplay, subjects further commented this mode in the following: "The game was a little easier to play with 3D enabled, as you could see the '3D-ness' of the world better.", "I found it much easier to control my dice, because it helped me understand the perspective better." and "3D was better ... because it's easy to judge the environment space."

In terms of enhanced immersion by 3D stereoscopy affecting gameplay, participants noted the following: "More concentration with 3D then [non-3D]" and "3D-Stereoscopy made me tunnel vision the game, like I lost all my awareness of my surrounding and everything [else] came black".

In-Game Parameters

Two paired-samples t-tests [7] and [9] were used to determine whether there were statistically significant mean differences in the tracked in-game parameters player score, player deaths and the subsequently calculated player performance, when presenting the game in 3D stereoscopic mode compared to non-3D monoscopic mode (see Table 1c and Figure 10). Player scores were normally distributed with a skewness of -1.011 (SE =

0.421) and kurtosis of 1.962 (SE = 0.821), but did not show a statistically significant difference between means ($p > 0.05$). Player deaths were normally distributed with a skewness of -0.878 (SE = 0.421) and kurtosis of 1.505 (SE = 0.821), but did not show a statistically significant difference between means ($p > 0.05$).

The increases and decreases in player performance relating to the two different modes show the same tendency as the chosen mode preference. Subjects who preferred the non-3D monoscopic mode also showed a decrease in player performance in 3D stereoscopic mode, with a mean difference of -2.161. Whereas, subjects who preferred the 3D stereoscopic mode also showed an increase in player performance, while playing in 3D stereoscopic mode, with a mean difference of 1.009.

Nicely Dicely and the next Iteration

In general, Nicely Dicely received really positive feedback and seemed to provide a lot of fun for participants. Its potential as a great party or couch game was highlighted by around a third of the subjects. A later version of Nicely Dicely provided tighter controls (by adjusting physics parameters), more mysteries (e.g. high gravity, low gravity and player cube shrinkage) and a fourth player action "paralyze", to temporarily paralyze other players in close range. The latter added a more direct competitive element and another way for scoring. Internal testing showed, that these additions positively influenced gameplay and fun, by making the game more versatile.

Conclusion

Relating our experiment's results to the initial hypothesis "3D stereoscopic vision increases player immersion, even in a possibly distracting local multiplayer game.",

we can make the two statements. Indeed, 3D stereoscopic vision significantly increases player immersion (including involvement and spatial presence), compared to non-3D monoscopic vision. As different evaluation tools were used, our results strengthen the primary outcomes of studies by Mahoney et al. [12] and Schild et al. [13]. Additionally, our study has expanded these outcomes by illustrating, that the increase in player immersion also applies in a possibly very distracting local multiplayer situation with up to four players. Furthermore, subjects' comments on an increased realness and graphical attractiveness, as well as a subjectively better gameplay, caused by an improved depth perception, are adding to the advantages of stereoscopic 3D. As such, we argue for the potential that stereoscopic 3D holds for digital games in general, but also for party and couch games with multiple parallel players.

Nevertheless, we agree with Mahoney et al. [12], that games need to be specifically designed for stereoscopic 3D, to deliver an enjoyable and superior experience to users. Providing meta information via overlaying HUDs for example, needs to be designed with great care. The version of Nicely Dicely tested in the experiment, spatially placed all HUDs (including the cooldown rings around the player cubes) at the zero-parallax distance in the front. Reviewing some participants' comments on eye strain and an increased demand for player concentration in stereoscopic 3D, we think this and the only slightly higher direct preference for 3D were caused by not spatially placing the ring HUDs at the same distance as the player cubes. In a later version of the game, the ring HUDs were completely redeveloped to be able to render with the same parallax shift as the corresponding player cubes. Internal testing showed, this relieved eye strain drastically, as users would not need to con-

stantly readjust their focus distance between the player cube and its surrounding ring HUD.

Similar to the study of Litwiller et al. [10], we could not find any effect on in-game player performance, related to the two different presentation modes. Nevertheless, there was an undetermined correlation between subjective direct mode preference and objective player performance. Subjects who preferred one mode, most likely also showed better player performance in this mode, compared to the other one.

Future Research

Limitations of the previous experiment were its relatively small sample size and play testing in a laboratory like manner. Future research could exceed these limitations and test the next iteration of Nicely Dicely for an increased effect on immersion and a higher direct preference for stereoscopic 3D.

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